1323-4C-ATTO

URS

October 21, 2008

Indiana Department of Environmental Management
100 North Senate Avenue
P.O. Box 6015
Indianapolis, IN 46206-6015

RECEIVED
OCT 23 2008
DEPARTMENT OF
ENVIRONMENTAL MANAGEMENT
OFFICE OF LAND QUALITY

Attention: Ms. Dawn Groves
State Cleanup Program, Office of Land Quality

Subject: Analytical Results
August 2008 Groundwater Monitoring
Tuchman Cleaners Facility
4401 North Keystone Avenue
Indianapolis, Indiana
Incident #1991-02-503

INTRODUCTION

On behalf of Tuchman Cleaners (Tuchman), URS prepared this letter to summarize the August 2008 groundwater monitoring event analytical results for the above-referenced facility. Initial groundwater monitoring for the second quarter of 2008 was conducted on June 26 and 27, 2008, but the groundwater samples expired before analytical testing was performed. At the request of Tuchman, URS performed a supplemental groundwater monitoring event in August 2008. Quarterly groundwater monitoring has been conducted between 2005 and the first quarter of 2008 at the request of the Indiana Department of Environmental Management (IDEM), State Cleanup Program (SCP).

MONITORING ACTIVITIES

The groundwater monitoring activities were conducted on August 2 and 7, 2008. Groundwater elevations were measured in all wells on August 2, 2008. The measured conditions represent the natural groundwater flow without the influence of pumping well RW-1, which is currently not in operation. Groundwater level measurements were collected using an electronic interface probe at wells where previous data suggest the potential presence of a separate dense non-aqueous phase liquid (DNAPL). The water level probe was generally decontaminated with a paper towel and distilled water prior to measurement at each well. At wells historically containing high volatile organic compound (VOC) concentrations, the interface probe was washed with an alconox solution and rinsed with distilled water after use.

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A representative set of monitoring wells was sampled on August 7, 2008. Sampling involved purging of the wells, measuring field parameters, and collecting samples for the analysis of VOCs including tetrachloroethene (PCE). Purging and sampling was performed using disposable polyethylene bailers and new lengths of nylon rope to eliminate the potential for cross contamination of the samples. Field measurements of temperature, pH, specific conductance, and oxidation-reduction potential (ORP) were made and recorded while purging each well. Groundwater samples were collected after a minimum of three well volumes of groundwater was purged and the field parameters stabilized. All purge water was contained and discharged into the onsite groundwater treatment system.

All groundwater samples were collected in laboratory-supplied glass vials and stored in an ice-chilled cooler. Samples were shipped via overnight courier to Microbac Labs (formerly Kemron Environmental Services) in Marietta, Ohio and analyzed for VOCs per United States Environmental Protection Agency (U.S. EPA) SW-846 Method 8260.

RESULTS

Data collected through sampling and analysis of monitoring wells on August 2 and 7, 2008 are summarized in Tables 1 and 2. The associated summary laboratory report is included electronically on a CD-ROM as Attachment 1.

GROUNDWATER FLOW

The groundwater level measurements collected during this event are presented in Table 1 along with measurements from the prior four sampling events (including the June 2008 groundwater level measurements) for comparison purposes. A piezometric surface map representing the shallow groundwater flow conditions is plotted on Figure 1. Figures 2 and 3 illustrate the potentiometric surface of the intermediate and deep groundwater zones, respectively.

The shallow groundwater piezometric surface map reflects a groundwater flow direction towards the west-southwest at a gradient ranging from 0.002 under the building to 0.0035 west of the building (Figure 1). The intermediate groundwater potentiometric surface map (Figure 2) indicates flow towards the west-southwest at a gradient on the order of 0.010. The deep groundwater potentiometric surface map (Figure 3) indicates a gradient of 0.028 towards the south-southwest, which is a change from the east-southeast and east-northeast directions observed in December 2007 and March 2008, respectively.

ANALYTICAL RESULTS

The groundwater sample results are summarized on Table 2. The chlorinated VOCs (CVOCs) reported in the sampled wells during this event were generally within the range of values detected in previous monitoring events. Some notable observations regarding the analytical results include:

- CVOC concentrations reported at MW-4 are the lowest levels since quarterly groundwater monitoring in 2004. CVOC levels have been generally trending downward since implementation of the pilot-scale bioremediation effort in June 2007.

- An upward trend in cis-1,2-dichloroethene concentrations is observed in the downgradient off site wells since December 2007, including a near ten-fold spike at MW-14 between March and August 2008 also indicative of bioremediation effects.

- The PCE concentration reported in intermediate well MW-2I (123 mg/L) has remained at levels in-line with values observed between June 2005 and June 2007. The PCE results during the second half of 2007 ranged from a high of 206 mg/L in September 2007 to a low of 9.3 mg/L in December 2007.

- CVOC concentrations in deep well MW-4D have dropped to levels below the IDEM residential default closure level (DCL) identified in the Risk Integrated System of Closure (RISC) technical guide.

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If there are any questions regarding these results, please do not hesitate to contact the undersigned at 513-651-3440 or Mr. Randy Jackson representing Tuchman Cleaners at 816-444-1223.

Very truly yours,
URS

William R. Eckhoff
Geologist

Dennis P. Connair, LPG #1535
Principal

14947802
Attachments

Copy: Mr. Randy Jackson

TABLE 1

GROUNDWATER ELEVATIONS
QUARTERLY GROUNDWATER SAMPLING - AUGUST 2008

TUCHMAN CLEANERS
4401 NORTH KEYSTONE AVENUE
INDIANAPOLIS, INDIANA

Well No.	Reference Elevation* (feet)	3/26/2007 Groundwater Elevation (feet)	6/18/07 Groundwater Elevation (feet)	9/26/07 Groundwater Elevation (feet)	12/5/07 Groundwater Elevation (feet)	3/25/08 Groundwater Elevation (feet)	8/2/08 Groundwater Elevation (feet)
MW-1	728.16	718.55	717.24	716.18	716.83	718.25	717.63
MW-1I	728.56 **	NM	712.61	709.63	715.23	714.28	708.76
MW-2I	727.51 **	708.91	717.93	716.47	717.55	719.2	709.46
MW-3	727.2	718.61	717.27	717.38	717.04	718.25	717.65
MW-3I	727.66 **	708.76	717.97	716.43	717.7	719.27	709.37
MW-4	727.71	718.48	717.24	716.16	716.7	718.24	717.67
MW-4I	727.55	708.63	718.01	716.44	717.64	719.26	709.26
MW-4D	727.56	701.24	715.76	713.76	715.58	717.14	701.62
MW-5	727.84	718.45	717.22	716.08	716.73	718.23	717.66
MW-6	728.33	719.25	717.78	716.8	717.41	718.85	718.18
MW-6I	728.22	712.45	717.17	715.38	717.54	718.97	712.07
MW-6D	728.2	706.1	714.66	713.55	715.04	716.54	705.45
MW-7	728.22	718.65	717.32	716.31	716.91	718.35	717.74
MW-8	727.87	718.57	717.31	716.24	716.83	718.31	717.72
MW-9	727.81	718.38	717.19	715.92	716.49	718.21	717.65
MW-10	728.56	718.68	717.47	716.43	717.05	718.46	717.88
MW-11	727.49	718.28	717.26	716.17	716.73	718.19	717.68
MW-12	728.08	718.19	717.28	716.18	716.85	718.18	717.69
MW-13	729.05	716.96	716.54	715.5	716.09	717.12	716.86
MW-13I	729.05	708.06	718.18	716.61	717.8	719.32	708.86
MW-14	728.4	717.3	716.48	NM	716.15	717.18	716.79
MW-14I	728.4	708.08	718.18	NM	717.8	719.32	708.87
MW-15	728.43	718.92	717.54	716.53	717.18	718.6	717.97
MW-16	727.37	719.07	717.57	716.62	717.18	718.6	717.95
MW-17	727.88	718.25	717.07	715.82	716.45	718.12	717.54
RW-3	728.31	NM	NM	NM	NM	715.41	NM
OSP-3	727.37	NM	NM	NM	NM	NM	NM
OSP-4	737.21	NM	NM	NM	NM	NM	NM
OSP-9	737.68	NM	NM	NM	NM	NM	NM
OSP-13	731.37	NM	NM	NM	NM	NM	NM
PZ-10D	727.99	705.79	715.49	714.81	715.51	716.92	705.14

* Monitoring wells were surveyed on February 20-26, 2003 and April 21, 2004 by Beacon Engineering of Indianapolis, Indiana. Reference elevations are relative to NAD 27 sea level datum.

** Monitoring wells were surveyed on September 13, 2004 by URS Corporation.

NM = Not Measured

TABLE 2

ANALYTICAL RESULTS SUMMARY

QUARTERLY GROUNDWATER SAMPLING - SECOND QUARTER 2008
AUGUST 7, 2008

TUCHMAN CLEANERS
4401 NORTH KEYSTONE AVENUE
INDIANAPOLIS, INDIANA

	RISC Closure Level*		Shallow Aquifer						
Parameters	**Residential**	**Industrial**	**MW-3**	**MW-4**	**MW-6**	**MW-11**	**MW-12**	**MW-13**	**MW-14**
TCL Volatile Organics (mg/L)									
Acetone	6.900	92	-	-	0.00251 J	-	-	-	-
Benzene	0.0055	0.052	-	-	-	0.00399 J	-	-	-
n-Butylbenzene	NR	NR	-	0.000589 J	-	-	-	-	-
sec-Butylbenzene	NR	NR	-	0.00537	-	-	-	-	-
tert-Butylbenzene	NR	NR	-	0.00171 J	-	-	-	-	-
Chlorobenzene	0.1	2	-	-	-	0.00502 J	-	-	-
Chlorodibromoethane			-	-	-	-	0.000726 J	-	-
Chloroethane	0.062	0.99	-	-	-	-	-	-	-
Chloromethane			-	-	-	-	-	0.00745 J	-
1,2-Dichlorobenzene	0.6	9.2	-	0.00152 J	-	-	-	-	-
1,4-Dichlorobenzene	0.075	0.12	-	0.00048 J	-	-	-	-	-
1,1-Dichloroethene	0.007	5.1	-	-	-	-	-	-	-
cis-1,2-Dichloroethene	0.070	1	0.00272	0.040	-	0.0205	-	0.686	0.711
trans-1,2-Dichloroethene	0.100	2	-	-	-	-	-	-	0.0071 J
Ethylbenzene	1.6	10	-	-	-	-	-	-	-
Isopropylbenzene	0.83	10	-	0.00136 J	-	-	-	-	-
p-Isopropyltoluene	NR	NR	-	-	-	-	-	-	-
Methylene chloride	0.063	0.38	-	-	-	-	-	-	-
Naphthalene	0.0083	2.0	-	-	-	-	-	-	-
n-Propylbenzene	0.31	4.1	-	-	-	-	-	-	-
Tetrachloroethene	0.005	0.055	0.087	0.272	0.0184	3.05	0.0205	3.3	0.276
Toluene			-	-	-	-	-	-	-
Trichloroethene	0.005	0.0072	0.0057	0.00931	-	0.0959	0.000563 J	0.122	0.147
1,2,4-Trimethylbenzene	0.016	5.1	-	0.000897 J	-	-	-	-	-
1,3,5-Trimethylbenzene	0.016	5.1	-	-	-	-	-	-	-
Vinyl Chloride	0.002	0.004	0.00141	0.027	-	-	-	0.0206 J	0.0413
Cumulative CVOC Concentration			0.097	0.34831	0.018	3.166	0.021	4.129	1.182
Field Parameters									
Oxidation-Reduction Potential (mV)			7	-127	57	51	41	21	-70
Specific Conductance (µmhos/cm)			1,023	992	980.6	883.7	904.6	913.8	1,109
pH (S.I.)			7.10	7.05	7.18	7.21	7.21	7.13	6.91
Temperature (Fahrenheit)			63.9	65.5	64.2	62.2	62.6	63.0	63.5

See last page for notes

TABLE 2 (Continued)

Parameters	RISC Closure Level* Residential	Industrial	Intermediate Aquifer MW-2I	MW-4I	MW-13I	Deep Aquifer MW-4D
TCL Volatile Organics (mg/L)						
Acetone	6.900	92	-	-	-	-
Benzene	0.0055	0.052	-	-	-	-
n-Butylbenzene	NR	NR	-	-	-	-
sec-Butylbenzene	NR	NR	-	-	-	-
tert-Butylbenzene	NR	NR	-	-	-	-
Chlorobenzene	0.1	2	-	0.0164 J	-	-
Chlorodibromoethane			-	-	-	-
Chloroethane	0.062	0.99	-	-	-	-
Chloromethane			-	-	-	-
1,2-Dichlorobenzene	0.6	9.2	-	-	-	-
1,4-Dichlorobenzene	0.075	0.12	-	-	-	-
1,1-Dichloroethene	0.007	5.1	-	-	-	-
cis-1,2-Dichloroethene	0.070	1	-	1.14	-	-
trans-1,2-Dichloroethene	0.100	2	-	-	-	-
Ethylbenzene	1.6	10	-	-	-	-
Isopropylbenzene	0.83	10	-	-	-	-
p-Isopropyltoluene	NR	NR	-	-	-	-
Methylene chloride	0.063	0.38	0.289 J	0.0261 J	-	-
Naphthalene	0.0083	2.0	-	-	-	-
n-Propylbenzene	0.31	4.1	-	-	-	-
Tetrachloroethene	0.005	0.055	123	18.6	-	0.001
Toluene			-	-	-	-
Trichloroethene	0.005	0.0072	0.819 J	3.02	-	0.00235
1,2,4-Trimethylbenzene	0.016	5.1	-	-	-	-
1,3,5-Trimethylbenzene	0.016	5.1	-	-	-	-
Vinyl Chloride	0.002	0.004	-	-	-	-
Cumulative CVOC Concentration			123.819	22.76	-	0.003
Field Parameters						
Oxidation-Reduction Potential (mV)			-133	-129	-119	-114
Specific Conductance (µmhos/cm)			897.9	915.7	864.4	821.7
pH (S.I.)			7.41	7.31	7.26	7.30
Temperature (Fahrenheit)			61.8	61.8	61.3	61.0

See last page for notes

TABLE 2 (Continued)

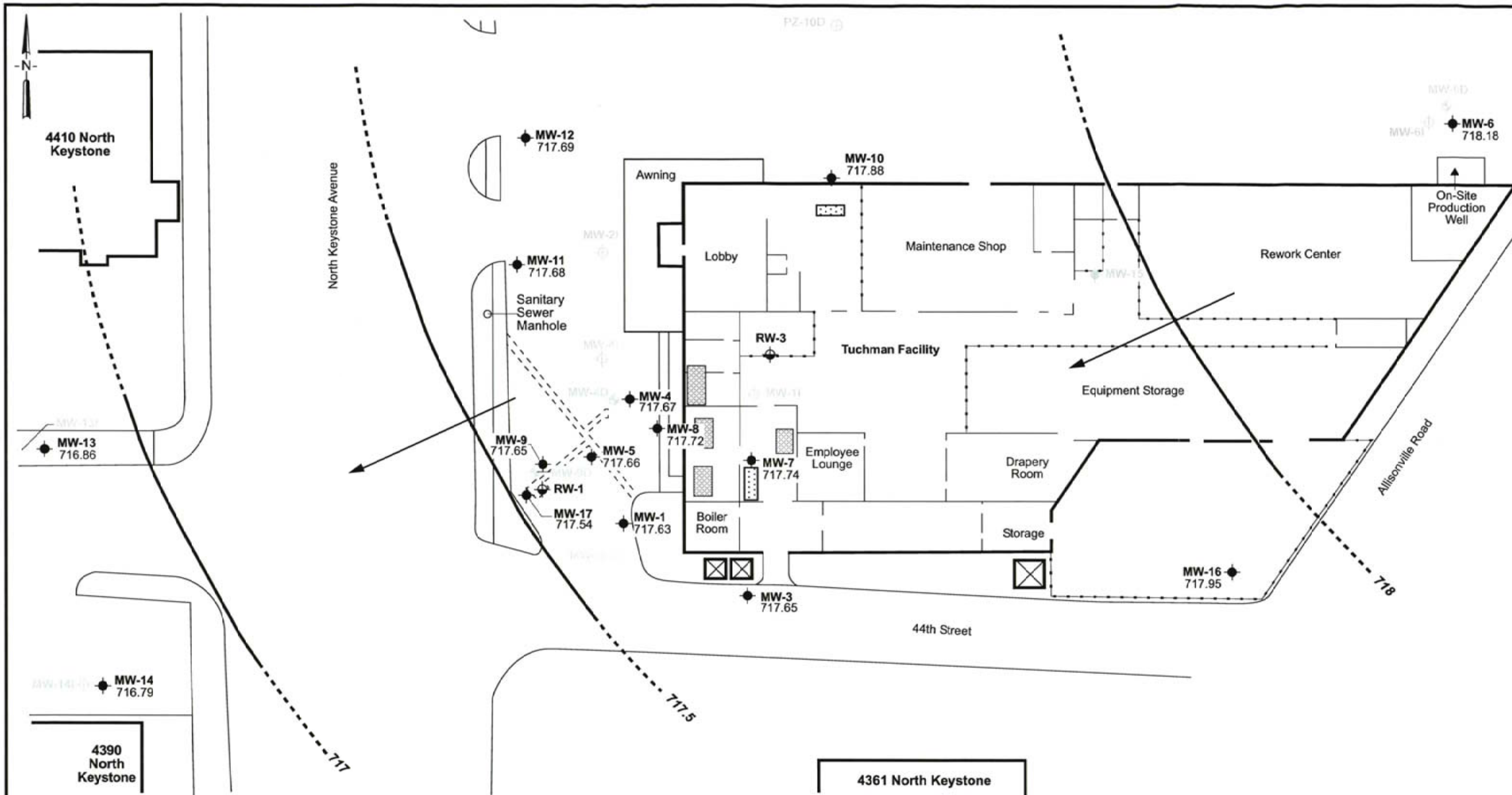
Groundwater samples were analyzed by KEMRON Environmental Services of Marietta, Ohio

"-" = Below detection limit
TCL = Target Compound List
NM = Not Measured
NS = Not Sampled
NA = Not Available
J = Estimated concentration below reporting limit
Q = One or more quality control criteria fail

<u>Underlined values</u> = Concentration exceeds RISC closure level for a residential setting

☐ = Concentration exceeds RISC closure level for an industrial setting
Risk Integrated System of Closure (RISC) Technical Guide (updated January 31, 2006)
* = RISC Closure levels are derived from Table A within Appendix A of the Indiana Department of Environmental Management (IDEM)
Risk Integrated System of Closure (RISC) Technical Guide (updated January 31, 2006)

NATIONAL DRY CLEANERS INC – 14947802.00203 - AUGUST 2008 - INDIANAPOLIS, INDIANA - CHECKED BY



LEGEND:

- Fence
- Equipment Storage Building
- Approximate Current Dry Cleaning Machine Location
- Approximate Former Dry Cleaning Machine Location
- MW-13 Shallow Monitoring Well Location
- MW-13I Intermediate Monitoring Well Location
- MW-6D Deep Monitoring Well Location
- PZ-10D Deep Piezometer Location
- RW-3 Recovery Well Location
- 717.5 Shallow Groundwater Surface Contour (Feet, msl) (Dashed Where Inferred)
- Apparent Shallow Groundwater Flow Direction
- (717.65) Shallow Groundwater Elevation (Feet, msl)

0 30 60

APPROXIMATE SCALE IN FEET

BASE MAP SOURCE: Drawn from Indianapolis Mapping and Geographic Infrastucture System (IMAGIS) 2001 aerial photograph with surveyed sampling coordinates referenced into IMAGIS aerial photograph/map.

TUCHMAN CLEANERS
4401 NORTH KEYSTONE AVENUE
INDIANAPOLIS, INDIANA

FIGURE 1
PIEZOMETRIC SURFACE MAP
SHALLOW GROUNDWATER ZONE
AUGUST 2, 2008

JOB NO. 14947802

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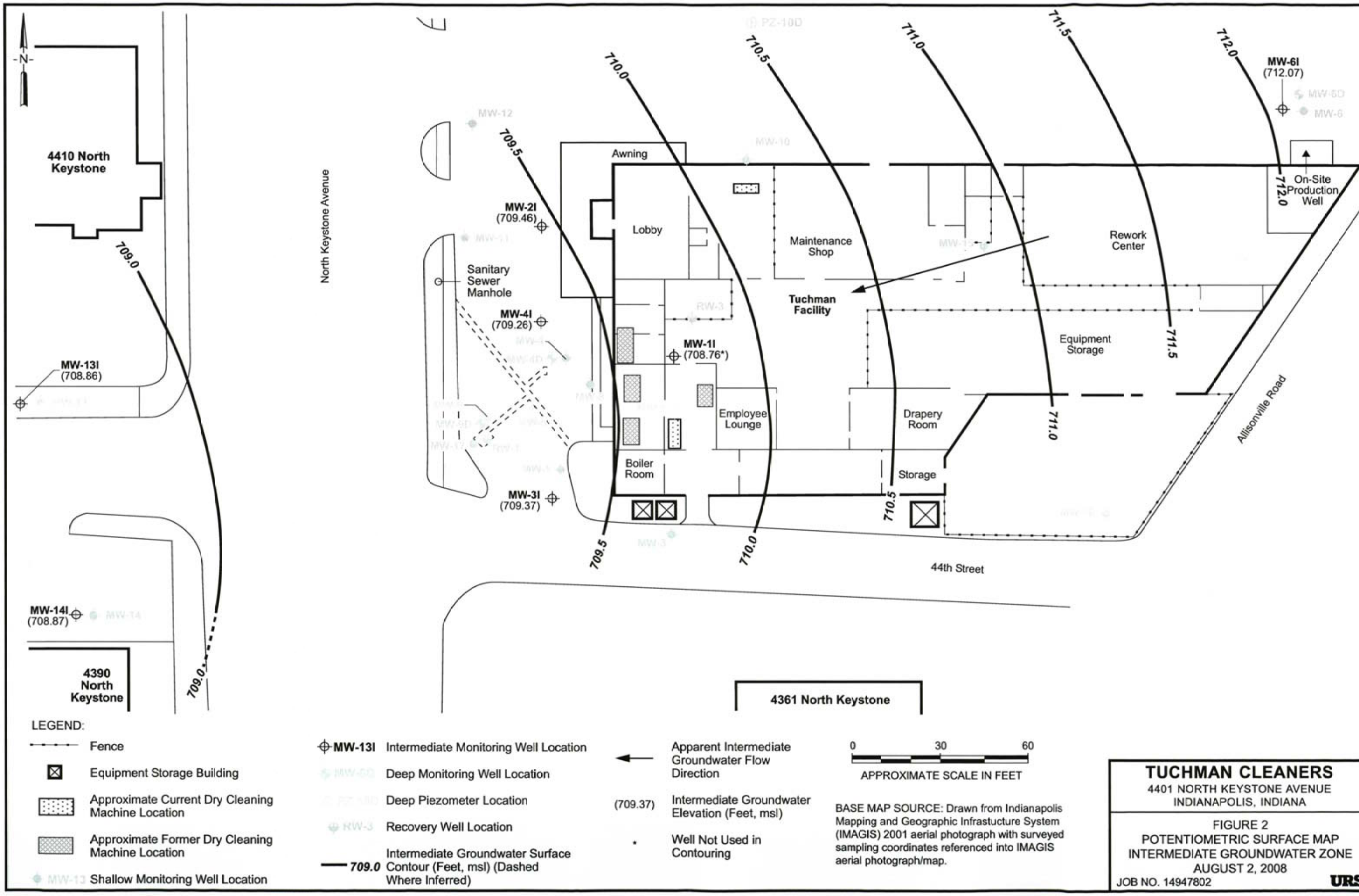

TUCHMAN CLEANERS
4401 NORTH KEYSTONE AVENUE
INDIANAPOLIS, INDIANA

FIGURE 2
POTENTIOMETRIC SURFACE MAP
INTERMEDIATE GROUNDWATER ZONE
AUGUST 2, 2008

JOB NO. 14947802

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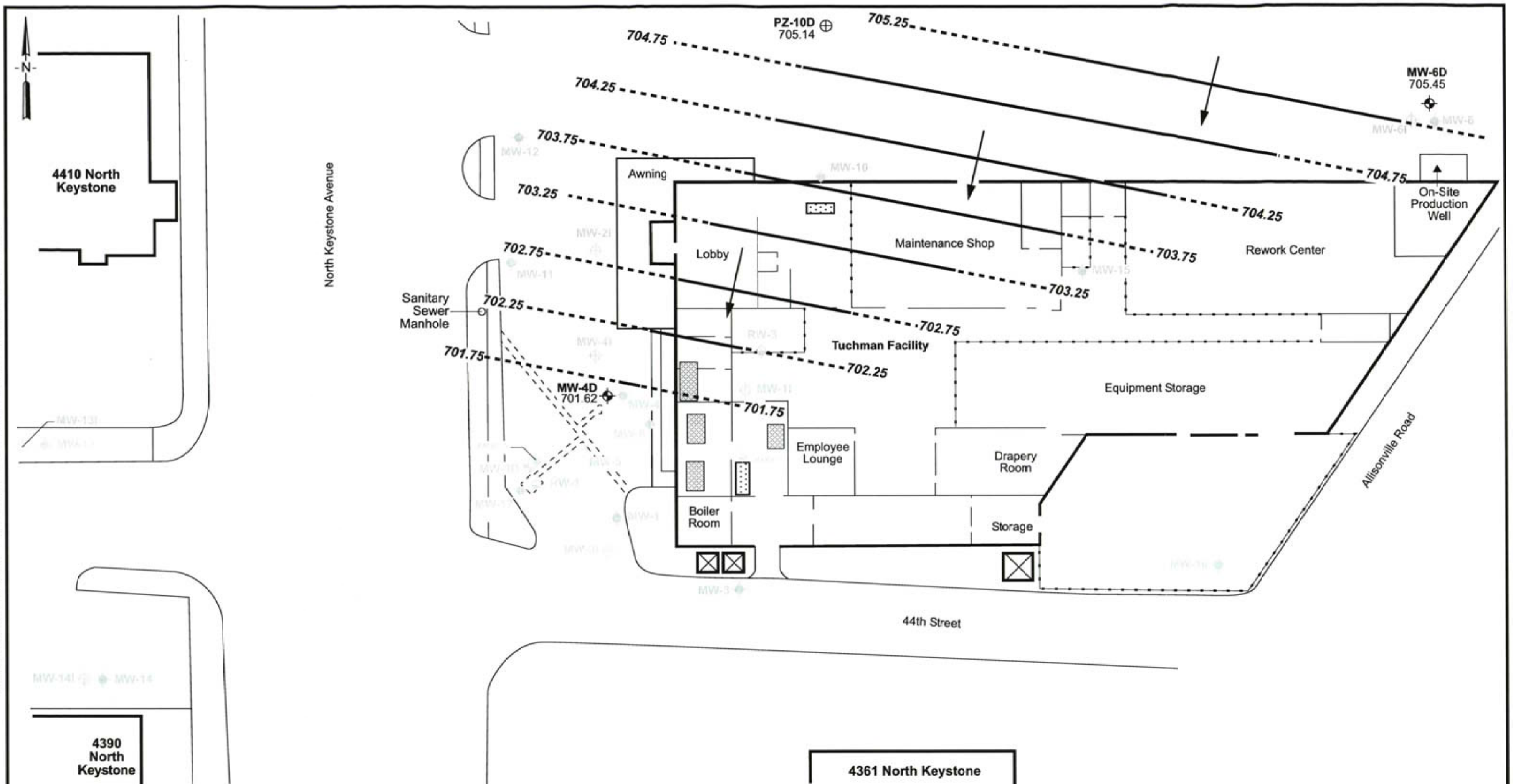

LEGEND:

Fence	MW-13I Intermediate Monitoring Well Location	Apparent Deep Groundwater Flow Direction	
Equipment Storage Building	MW-6D Deep Monitoring Well Location		
Approximate Current Dry Cleaning Machine Location	PZ-10D Deep Piezometer Location	(705.45) Deep Groundwater Elevation (Feet, msl)	
Approximate Former Dry Cleaning Machine Location	RW-3 Recovery Well Location		
MW-13 Shallow Monitoring Well Location	702.75 Deep Groundwater Surface Contour (Feet, msl) (Dashed Where Inferred)		

0 30 60

APPROXIMATE SCALE IN FEET

BASE MAP SOURCE: Drawn from Indianapolis Mapping and Geographic Infrastucture System (IMAGIS) 2001 aerial photograph with surveyed sampling coordinates referenced into IMAGIS aerial photograph/map.

TUCHMAN CLEANERS
4401 NORTH KEYSTONE AVENUE
INDIANAPOLIS, INDIANA

FIGURE 3
POTENTIOMETRIC SURFACE MAP
DEEP GROUNDWATER ZONE
AUGUST 2, 2008

JOB NO. 14947802

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ATTACHMENT 1

GM

Worldwide Facilities Group
Environmental Services
Remediation Team

October 22, 2008

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OCT 23 2008

DEPARTMENT OF
ENVIRONMENTAL MANAGEMENT
OFFICE OF LAND QUALITY

Ms. Nilia Moberly Green
Indiana Department of Environmental Management
State Cleanup Section
Indiana Government Center North
100 North Senate Avenue
Indianapolis, IN 46204

Re: Vapor Intrusion Evaluation
General Motors Corporation
Columbus Avenue Facility, Anderson, Indiana
Incident # 1999-06-010

Dear Ms. Green,

General Motors Corporation (GM) previously submitted "Responses to September 10, 2007 IDEM Comments on the GM December 12, 2006 Draft Responses to Comment Document" dated January 21, 2008 for the above referenced site to the Indiana Department of Environmental Management (IDEM). In this document, GM committed to undertake a further evaluation of the potential for vapor intrusion from groundwater in the vicinity of the site. GM completed this evaluation between January 2008 and August 2008, the results of which are summarized in the attached memorandum prepared by Conestoga-Rovers & Associates (CRA), with contributions from ENVIRON International Corporation (ENVIRON). Three copies of the memorandum have been provided to assist IDEM with their review of the vapor intrusion evaluation.

IDEM's review and written comments or approval of the memorandum is requested. Please contact me at (810) 656-3194 if you have any questions or comments.

Sincerely,

Dawn E. Cleary

Dawn E. Cleary
GM Remediation Team

Cc: Greg Carli, CRA
Jean Caufield, GM
Steve Song, ENVIRON

CONESTOGA-ROVERS & ASSOCIATES

261 Martindale Road, Unit #3
St. Catharines, Ontario L2W 1A2
Telephone: (905) 682-0510 Fax: (905) 682-8818
www.CRAworld.com

MEMORANDUM

TO:	Dawn Cleary	REF. NO.:	13048-10
FROM:	Greg Carli/Golnoush Bolourani/056/STC	DATE:	October 20, 2008
C.C.:	Jean Caufield, Meredith Anthony, Ian Richardson, Steve Song, Kun Zhao		
RE:	**Vapor Intrusion Evaluation GM - 2401 Columbus Avenue Facility Anderson, Indiana**		

INTRODUCTION

As discussed in General Motors Corporation (GM's) "Responses to September 10, 2007 IDEM Comments on the GM December 12, 2006 Draft Responses to Comment Document" dated January 21, 2008, and the Quarterly Progress Report No. 17 dated March 2008, GM has undertaken a further evaluation of the potential for vapor intrusion from groundwater in the vicinity of the 2401 Columbus Avenue Site, in Anderson, Indiana (Site). Specifically, the further evaluation focused on the potential for constituents associated with the chlorinated volatile organic compound (CVOC) plume to volatilize and migrate into buildings in the residential areas adjacent to the Site. This memorandum has been prepared by Conestoga-Rovers & Associates (CRA), with contributions from ENVIRON International Corporation (ENVIRON), to summarize the activities that occurred between January 2008 and August 2008 to support the evaluation and the results of the evaluation.

To support the further evaluation of the potential for vapor intrusion from groundwater, the following activities were conducted:

1. review of existing information pertaining to the soil types and vadose zone geology at and in the vicinity of the Site;
2. review of historical depths to groundwater in the shallow aquifer;
3. sampling of shallow monitoring wells associated with the Site to develop current trichloroethene (TCE) concentration contours to identify areas with the highest potential for vapor intrusion from groundwater;
4. a mapping of building types (e.g., full basement, crawl space, slab on grade) in the residential area to the northwest of the Site; and
5. Installation and sampling of soil gas probes at two on-site areas that based on groundwater concentrations and stratigraphy are expected to be the worst case for vapor intrusion.

REVIEW OF VADOSE ZONE GEOLOGY

In an effort to identify areas that would have the highest potential for vapor intrusion from groundwater, GM reviewed the soil boring logs from investigations conducted from 1998 to 2008 for key stratigraphic features of the vadose zone that are relevant to the potential for vapor intrusion from groundwater. The review showed that the vadose zone geology in the vicinity of the Site consists of a fill material underlain by a clay overburden unit. The depth of the clay overburden ranges from a minimum of 5 feet below ground surface (bgs) at former Plant 5 and near the MW18 well cluster, to as deep as 28 feet bgs in the residential neighborhood located north of former Plant 5. The thickness of the clay layer is important to the evaluation because the thickness of the clay layer beneath a building (which also depends on the building's type of foundation) is a key factor in determining the degree to which vapor migration from the water table to the building foundation will be reduced. Figure 1 presents a contour map of the depth to bottom of clay overburden generated from the soil boring logs that were reviewed. As shown on Figure 1, the clay overburden extends throughout the Site and surrounding area and, with a few exceptions, is generally 10 feet or more in depth.

SHALLOW GROUNDWATER DEPTHS

Similar to the depth to the bottom of the clay overburden unit, CRA reviewed historical groundwater depths for monitoring wells screened in the upper portion of the shallow aquifer (i.e., at or near the water table) to develop a contour map of the distance from the ground surface to the groundwater table. Contour maps based on the groundwater depths collected in March 2005 and November 2007 are presented on Figures 2 and 3, respectively. It should be noted that there is significant difference between the depth to groundwater in March 2005 compared to November 2007 (i.e., 3 feet or more in some areas), however, the general pattern is similar. Based on the March 2005 data, which represents the higher groundwater condition, there is typically 10 to 15 feet of unsaturated soil, predominantly consisting of sand, between the bottom of the overburden clay and the water table at and in the vicinity of the Site.

GROUNDWATER TCE CONTOURS

As noted in Quarterly Progress Report (QPR) No. 18, groundwater from twenty-nine monitoring wells was sampled over six days between April 21 and May 6, 2008 to support further assessment of potential for vapor intrusion. The results of the sampling, which were presented in QPR No. 18, were used to develop TCE concentration contours for the upper portion of the aquifer (i.e., using only monitoring wells screened at the water table). The TCE contours are presented on Figure 4. TCE contours presented on Figure 4 include the Indiana Department of Environmental Management (IDEM) Risk Integrated System of Closure (RISC) residential groundwater default closure level of 5 μg/L (which is the same as the MCL), a generic default vapor intrusion criterion of 37 μg/L which is based on IDEM guidance, and a concentration 10 times higher (370 μg/L). The 37 μg/L criterion was derived from Table 5 of the IDEM's 2006 draft vapor intrusion guidance by conservatively assuming an exposure period of 30 years and sand as the soil type, and then interpolating to a site-specific 13-foot depth to groundwater. The 370 μg/L contour was included because IDEM's 2006 draft vapor intrusion guidance says that IDEM believes soil gas sampling and possibly indoor air sampling are generally warranted where groundwater concentrations exceed 10 times the vapor intrusion criteria.

The vapor intrusion criterion was conservatively based on sand and interpolated from Table 5 (Commercial Ground Water Screening Levels) because the clay overburden overlying the groundwater plume is only 5 feet thick at a small area on-site, and in the event that a building with a basement were to be constructed in this area, the soil underlying the basement would be sand. An alternate criterion based on a loam soil type and interpolating from Table 4 (Residential Ground Water Screening Levels) was also considered, because the clay overburden overlying the plume in the off-site residential area is at least 10 feet thick and would not be penetrated by a basement. (A loam soil was considered for the alternate criterion because Table 4 does not include criteria based on clay.) However, a vapor intrusion criterion based on loam and interpolated from Table 4 to a site-specific 13-foot depth to groundwater would be approximately 41.5 µg/L, which is slightly less conservative than 37 µg/L. As such, the more conservative value of 37 µg/L was used in contouring the groundwater data.

As shown on Figure 4, the 370 µg/L contour is entirely within the Site or adjacent properties where current and reasonably foreseeable future land use is commercial or industrial. The 370 ug/L contour does not extend into the residential area located north of former Plant 5.

RESIDENTIAL DWELLING TYPES

GM conducted a survey of foundation types for the residential properties located on Pearl Street, Walnut Street, and Nobel Street between 23rd Street and 25th Street. The properties were classified into the following four categories based on the building construction features:

- Type-I: Buildings with a crawl space;
- Type-II: Buildings with a basement;
- Type-III: Buildings with a side-split construction; and
- Type-IV: Buildings with slab on grade.

The results of the building type survey are presented on Figure 5. Figure 5 also shows the depth to the bottom of the clay overburden in the residential area north of former Plant 5 (i.e., from Figure 1) and the TCE concentration contours presented on Figure 4. Based on the screening process performed and the analysis of clay thickness throughout the Site, the following conclusions were made:

- No residential buildings are located near the TCE concentration contour of 370 µg/L;
- Three Type-I (i.e., crawl space) residential properties are present over the vicinity of TCE concentration contour of 37 µg/L, however, the depth to bottom of clay overburden in this area is between 10 to 12 feet bgs. Therefore, it is highly unlikely that the clay overburden would have been compromised during construction of these dwellings; and
- There are three residential buildings above the IDEM RISC TCE concentration contour of 5 µg/L. Two of the properties are Type-II and one of them is Type-I. The depth to bottom of clay overburden in this area is 12 to 14 feet bgs. Therefore, it is highly unlikely that the clay overburden would have been compromised during construction of these dwellings.

SOIL GAS PROBE INSTALLATION AND SAMPLING

In March 2008, GM installed two soil gas probes (GP-1 and GP-2) at former Plant 5 that were screened at the interval just below the clay overburden. The locations of the soil gas probes are shown on Figure 6, and the stratigraphic logs for the probes are provided in Attachment A. The two probes were installed at locations that are expected to be the worst-case for vapor intrusion if buildings were to be constructed over the groundwater plume. Specifically, GP-1 was installed above the groundwater contaminant plume where the highest TCE concentrations were observed adjacent to the residential area. The monitoring well nearest GP-1 is MW-14S, as shown on Figure 6. In the most recent groundwater sample from MW-14S, which was collected in May 2008, the TCE concentration was 1.6 mg/L. Figure 6 and Attachment A show that the depth to the bottom of the clay overburden at GP-1 is approximately 9 feet. GP-2 was installed where the depth to the bottom of the clay overburden is the shallowest. As shown on Figure 6 and in Attachment A, the depth to the bottom of the clay overburden at GP-2 is approximately 5 feet. The monitoring well nearest GP-2 is MW-15, which had a TCE concentration of 0.92 mg/L in the most recent sample collected in May 2008.

On July 11, 2008, CRA sampled the two soil gas probes for TCE, cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride and submitted the samples to TestAmerica laboratory of Santa Ana, California. The results of the samples, including one field duplicate at GP-1, one ambient air sample, and one trip blank are presented in Table 1. In the duplicate pair from GP-1, only TCE was detected and it was detected at a concentration of 3.6 mg/m^3 in both samples. In the sample from GP-2, cis-1,2-DCE was detected at 0.01 mg/m^3 and TCE was detected at 0.89 mg/m^3. None of the three VOCs was detected in the ambient air sample or in the trip blank.

INTERPRETATION OF SOIL GAS DATA

The significance of the soil gas data at GP-1 and GP-2 was evaluated by placing a hypothetical residential building at each soil gas sample location, estimating the indoor air concentrations in the building due to vapor intrusion from the soil gas, and then calculating the cancer risk and hazard index for the predicted indoor air concentrations. The evaluation was performed for TCE. The evaluation was not necessary for cis-1,2-DCE because the soil gas concentration of 0.01 mg/m^3 is lower than the reference concentration (RfC) of 0.035 mg/m^3 that is calculated by route-to-route extrapolation from the oral reference dose (RfD) recommended by U.S. EPA as a Provisional Peer Reviewed Toxicity Value (PPRTV). This means the soil gas concentration of cis-1,2-DCE detected at GP-2 is safe to breathe directly as indoor air. The results of the evaluation for TCE show that the TCE concentrations detected in the soil gas at GP-1 and GP-2 do not pose a significant vapor intrusion risk, which also means the groundwater plume is unlikely to pose a significant vapor intrusion risk anywhere off-site. The following is a summary of the evaluation.

The TCE concentration in the indoor air of the hypothetical building at each soil gas sample location was calculated by multiplying the soil gas TCE concentration by an attenuation coefficient (α) that was calculated using U.S. EPA's Soil Gas-Advanced Model (SG-ADV) spreadsheet adaptation of the Johnson and Ettinger model (U.S. EPA 2004). The spreadsheet calculations for α are shown in Attachment B. As shown in Attachment B, the characteristics of the hypothetical residential building were conservatively set to the U.S. EPA default values. Soil in the foundation cracks was conservatively assumed to be "dry" sand. The soil between the foundation and the GP-1 soil gas sample was set to clay, based on the stratigraphic log for GP-1 (see Attachment A). At GP-2, where the clay overburden is shallower than the basement depth, the calculations were performed by conservatively assuming that the GP-2 sample was collected immediately below the foundation in sand.

The calculations in Attachment B show that the attenuation coefficients for TCE at GP-1 and GP-2 are 1.5×10^{-3} and 4.7×10^{-3}, respectively, and the corresponding indoor air concentrations in the hypothetical residential basement are 0.0053 mg/m^3 and 0.0024 mg/m^3. Using a TCE unit risk factor (URF) of 1.7×10^{-3} per mg/m^3, which U.S. EPA's NCEA recommended in 1995 (U.S. EPA 1995), the cancer risk associated with these indoor air concentrations are 3.7×10^{-6} and 1.7×10^{-6}. These cancer risks are well below the acceptable limit of 10^{-4}. If one were to use IDEM's 2005 interim URF of 1.5 x 10^{-2} per mg/m^3 for residential exposures, the cancer risks would be 3.3 x 10^{-5} and 1.5 x 10^{-5}, which are still well below the acceptable limit of 10^{-4}. The estimated indoor air concentrations are also much lower than the Agency for Toxic Substances and Disease Registry's (ATSDR's) intermediate minimal risk level (MRL) of 0.54 mg/m^3, which means they do not pose a significant noncancer risk either.

It should be noted that the U.S. EPA default assumptions used for calculating the attenuation coefficients in this evaluation are more conservative than necessary for estimating reasonable maximum exposures (RME). As such, the risk estimates calculated in the evaluation and discussed above are not RME risk estimates, and should be considered as upper-bound risk estimates. For example, U.S. EPA's default air exchange rate of 0.25 per hour is an extreme low value that is representative of seasonal conditions in highly energy-efficient residential buildings, and is not likely to represent long-term conditions in the residential buildings in the vicinity of the Site, which are the conditions that should be used in RME cancer risk calculations. The risk assessment previously conducted for the Site used an air exchange rate of 1 per hour which was believed to be appropriate for estimate the RME. Using this air exchange rate would decrease by a factor of four the attenuation coefficients, and thereby, the estimated indoor air concentrations discussed above.

Another reason the risk estimates discussed above should be considered upper-bound estimates is that the soil gas data were collected at worst-case locations. As discussed earlier, the soil gas data at GP-1 were collected where the concentration of TCE in groundwater adjacent to the residential area is the highest. At off-site locations in the vicinity of existing residences, the TCE concentrations in groundwater are much lower, as shown on Figure 4. In addition, the clay overburden off-site in areas overly the TCE groundwater plume is also thicker than that at GP-1 and GP-2, which would result in lower attenuation coefficients and lower estimated indoor air concentrations.

In summary, using worst-case soil gas data and worst-case assumptions for building characteristics, the upper-bound risk estimates calculated in the evaluation are still well within acceptable limits. As such, it can be concluded that the groundwater plume does not pose a vapor intrusion threat to off-site residents.

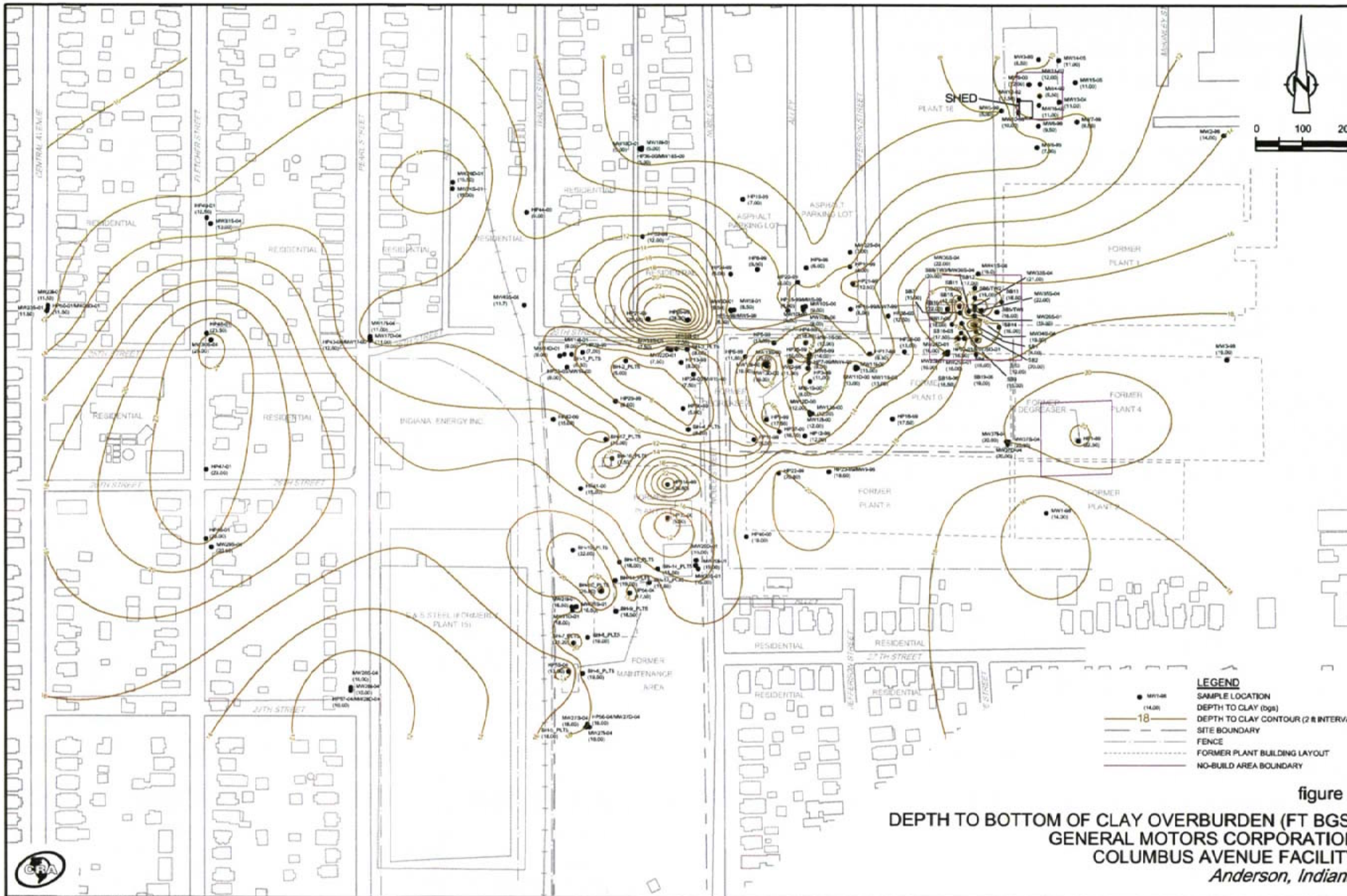
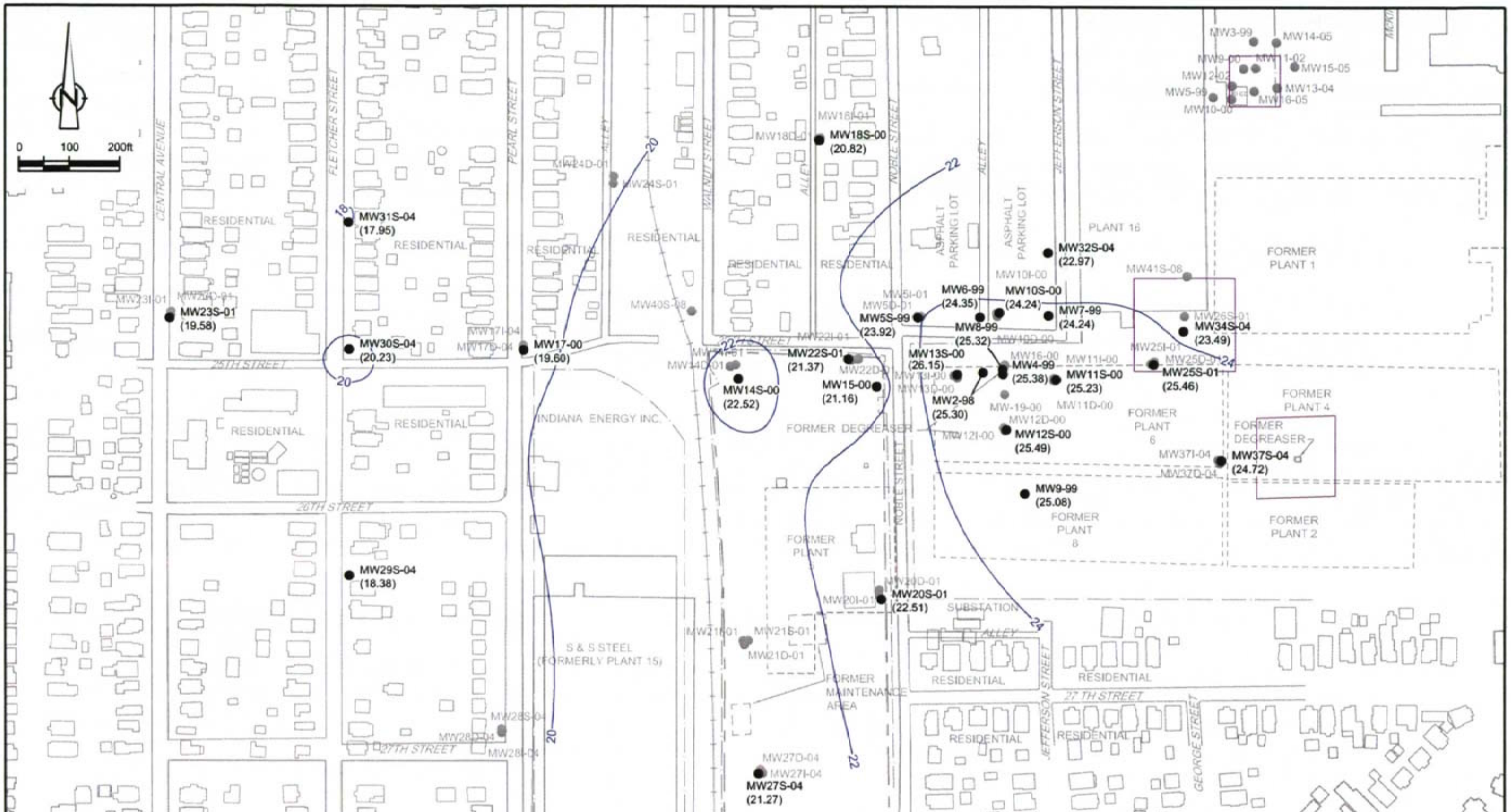


figure 1

DEPTH TO BOTTOM OF CLAY OVERBURDEN (FT BGS)
GENERAL MOTORS CORPORATION
COLUMBUS AVENUE FACILITY
Anderson, Indiana

013048-10(MEMO056)GN-SC001 OCT 16/2008



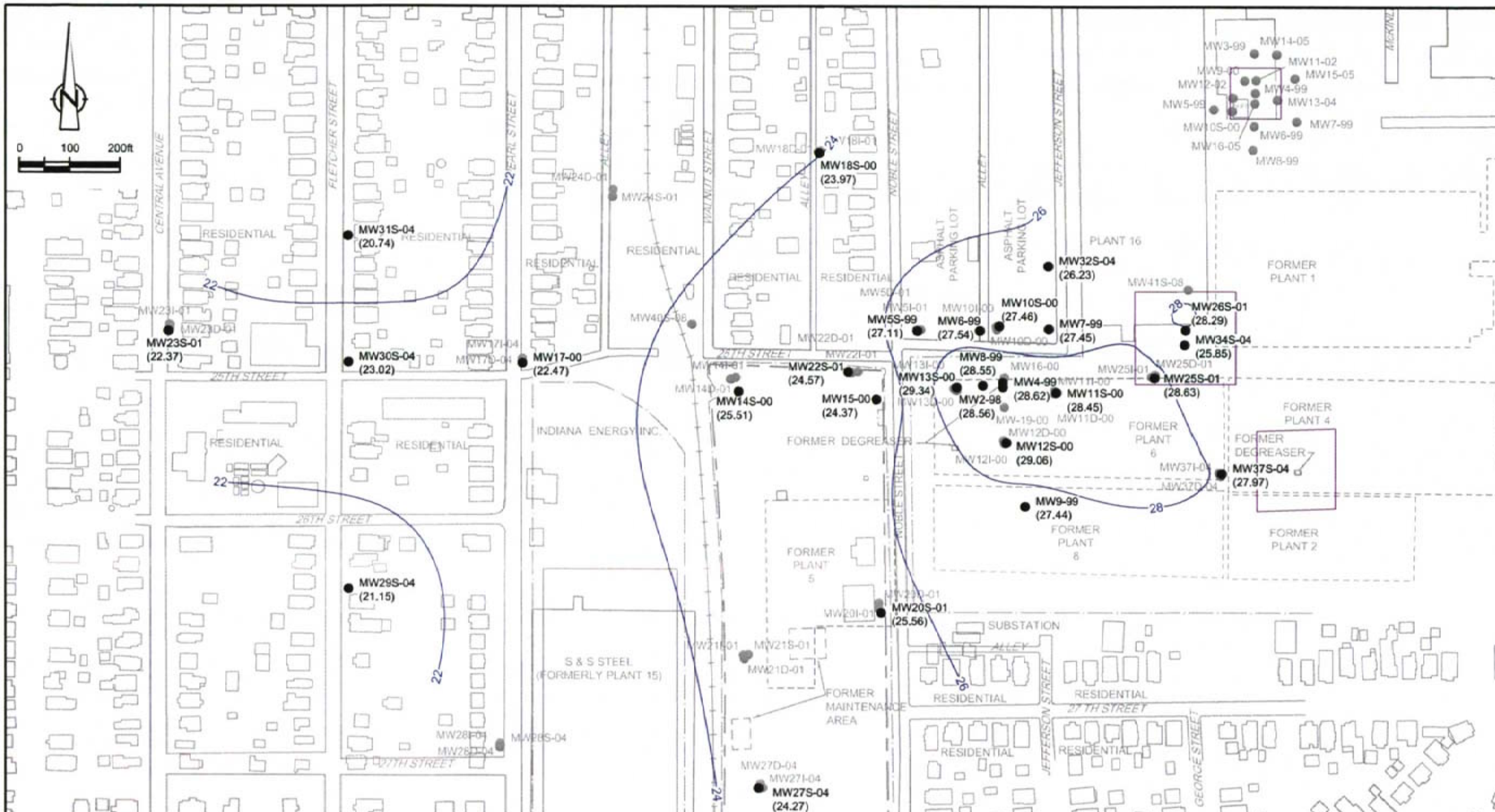
LEGEND

MW28S-04 ●	MONITORING WELL LOCATION
MW27D-04 ●	HYDROPUNCH/MONITORING WELL LOCATION
(3.90)	GROUNDWATER DEPTH (ft bgs)
	SITE BOUNDARY
	FENCE
	FORMER PLANT BUILDING LAYOUT
10	GROUNDWATER DEPTH MEASURED FEET BELOW GROUND SURFACE
	NO-BUILD AREA BOUNDARY

figure 2

GROUNDWATER DEPTH, MARCH 2005 - SHALLOW
GENERAL MOTORS CORPORATION
COLUMBUS AVENUE FACILITY
Anderson, Indiana

013048-10(MEMO056)GN-SC002 OCT 16/2008



LEGEND

MW29S-04 ●	MONITORING WELL LOCATION
MW27D-04 ●	HYDROPUNCH/MONITORING WELL LOCATION
(21.15)	GROUNDWATER DEPTH (ft bgs)
	SITE BOUNDARY
	FENCE
	FORMER PLANT BUILDING LAYOUT
10	GROUNDWATER DEPTH MEASURED FEET BELOW GROUND SURFACE
	NO-BUILD AREA BOUNDARY

figure 3

GROUNDWATER DEPTH, NOVEMBER 2007 - SHALLOW
GENERAL MOTORS CORPORATION
COLUMBUS AVENUE FACILITY
Anderson, Indiana

013048-10(MEMO056)GN-SC003 OCT 16/2008

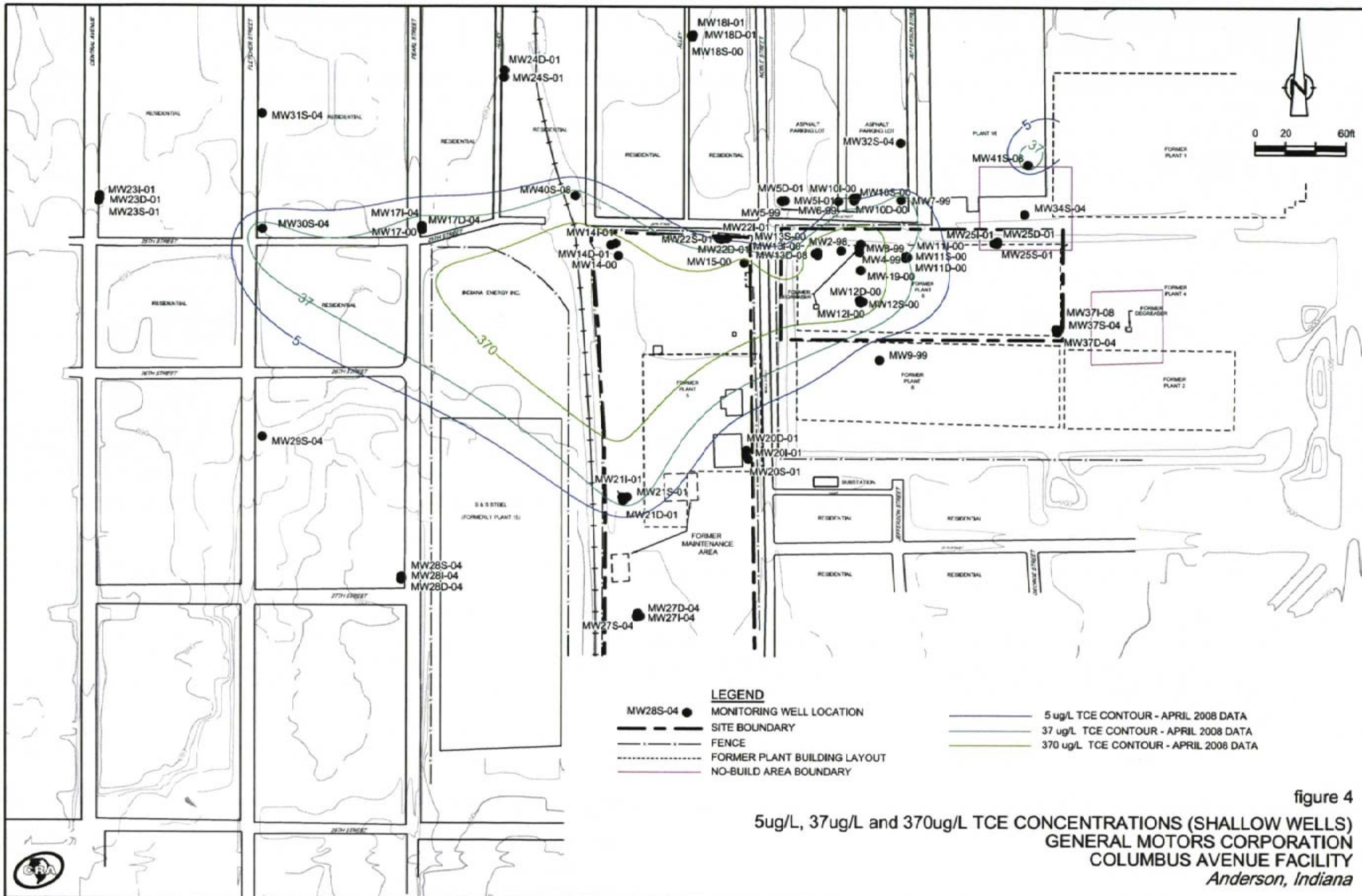
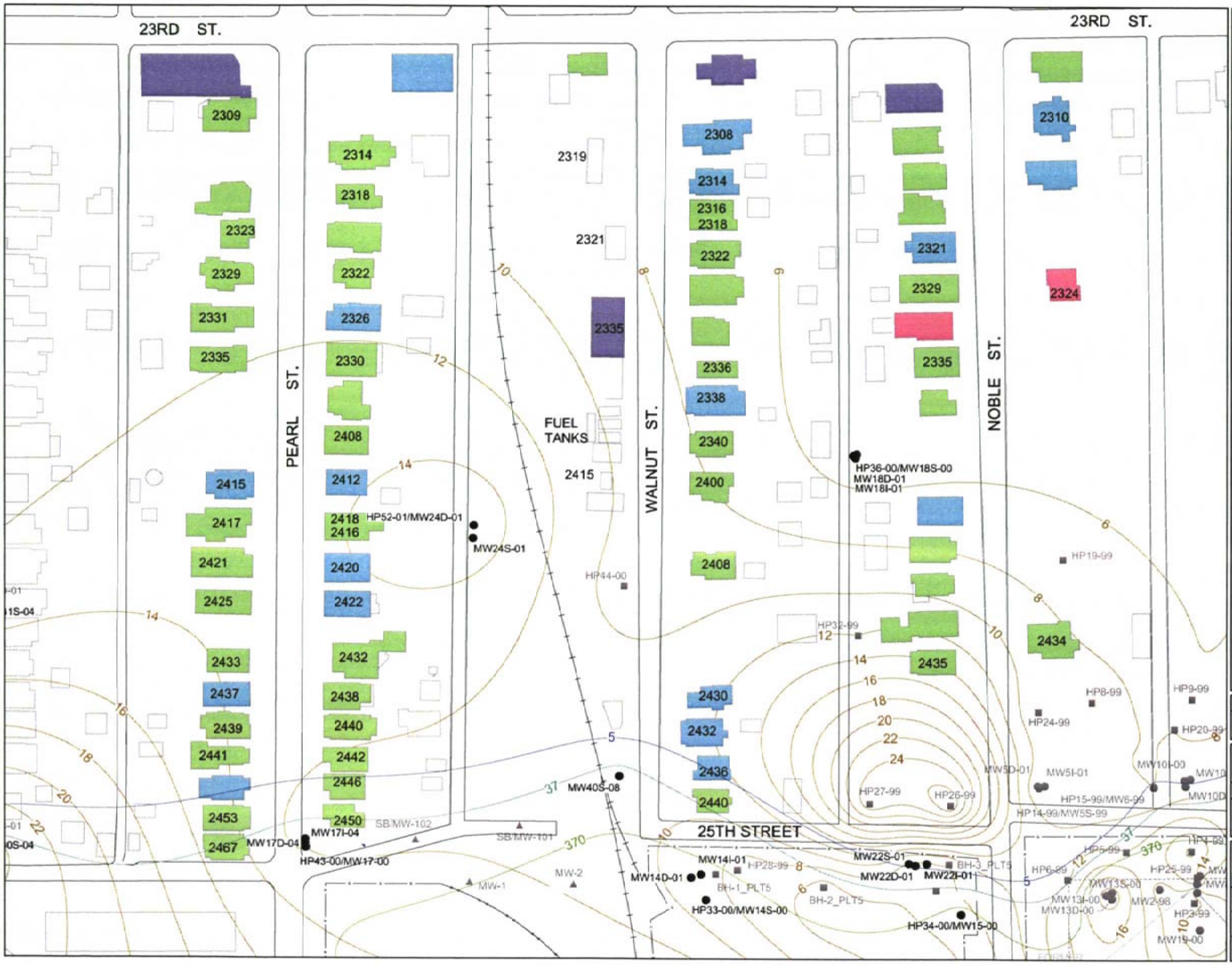


figure 4

5ug/L, 37ug/L and 370ug/L TCE CONCENTRATIONS (SHALLOW WELLS)
GENERAL MOTORS CORPORATION
COLUMBUS AVENUE FACILITY
Anderson, Indiana

013048-10(MEMO056)GN-SC004 OCT 16/2008



LEGEND

- RAILROAD
- FENCE LINE
- FORMER PLANT BUILDING LAYOUTS
- BUILDING
- MONITORING WELL LOCATION
- SOIL BORING LOCATION
- SOIL BORING/MONITORING WELL INSTALLED BY RETEC AND BEI
- ABANDONED MONITORING WELL
- HOMES WITH A CRAWL SPACE
- HOMES WITH A BASEMENT
- HOMES WITH A SIDESPLIT CONSTRUCTION
- HOMES WITH SLAB ON GRADE
- 2310 HOUSE NUMBER
- CLAY ELEVATION CONTOUR (2 ft INTERVALS)
- 5 ug/L TCE CONTOUR
- 37 ug/L TCE CONTOUR
- 370 ug/L TCE CONTOUR

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

RESIDENTIAL BASEMENT SURVEY

2401 COLUMBUS AVENUE FACILITY
ANDERSON, INDIANA

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
G.CARLI	P.LAMBERT	OCTOBER 2008	
Scale: 1"=100'	Project Nº: 013048-10	Report Nº: MEMO056	Drawing Nº: figure 5

013048-10(MEMO056)GN-SC006 OCT 16/2008

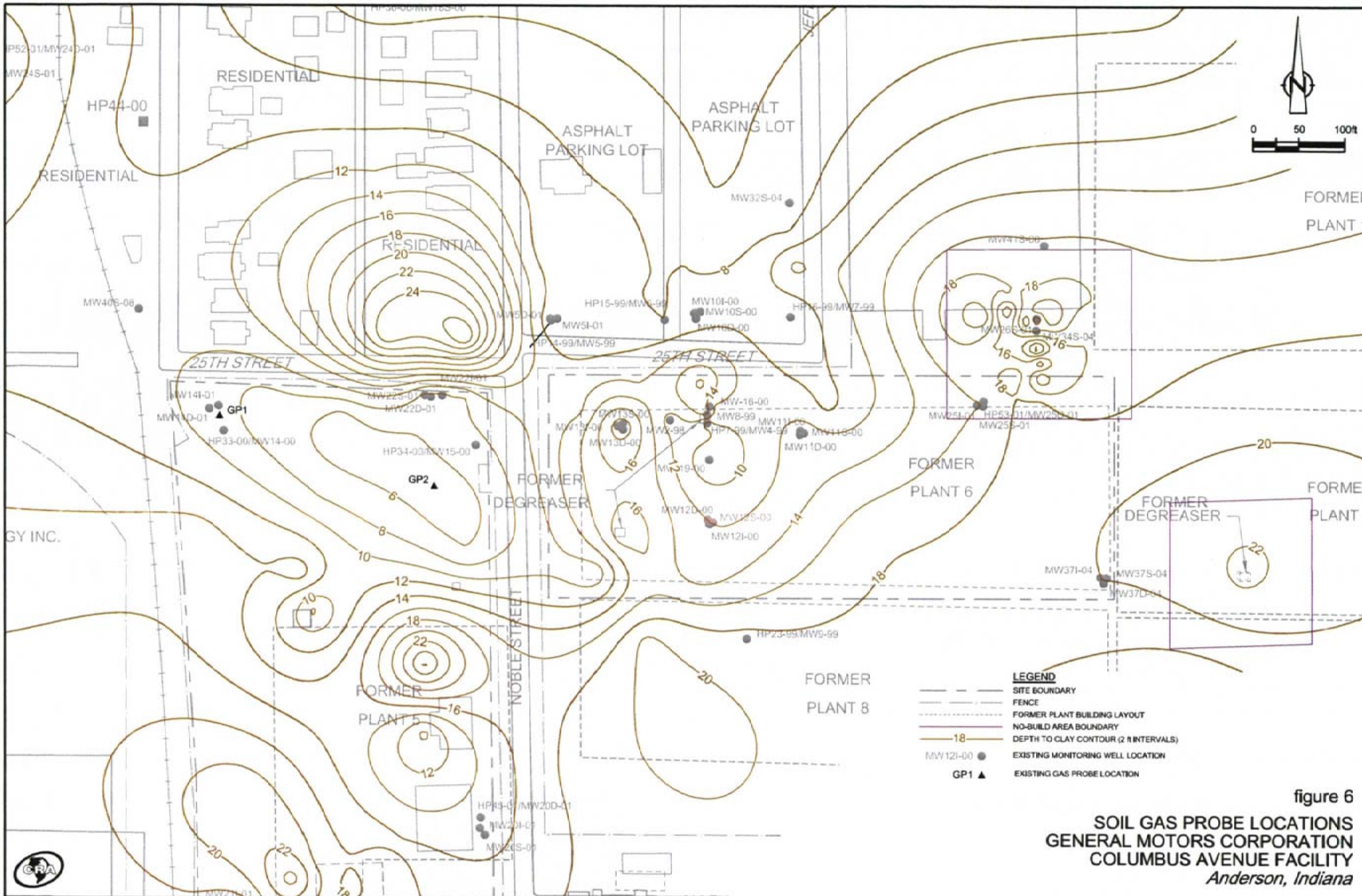


figure 6

SOIL GAS PROBE LOCATIONS
GENERAL MOTORS CORPORATION
COLUMBUS AVENUE FACILITY
Anderson, Indiana

013048-10(MEMO056)GN-SC007 OCT 16/2008

TABLE 1

SOIL GAS SAMPLING RESULTS
VAPOR INTRUSION PATHWAY EVALUATION
GM- 2401 COLUMBUS AVENUE FACILITY
ANDERSON, INDIANA

Sample Location		*AMBIENTBLANK*	*GP1*	*GP1*	*GP2*	*Trip Blank*
Sample ID		*AA-013048-071108-NH-001*	*SG-013048-071108-NH-002*	*SG-013048-071108-NH-003*	*SG-013048-071108-NH-001*	*TB-013048-071108-NH-001*
Sample Date		*7/11/2008*	*7/11/2008*	*7/11/2008*	*7/11/2008*	*7/11/2008*
Sample Type				*Duplicate*		
	Units					
Volatile Organic Compounds						
cis-1,2-Dichloroethene	ug/m3	0.79 U	4.2 U	7.1 U	10	0.79 U
Trichloroethene	ug/m3	2.1 U	3600	3600	890	2.1 U
Vinyl chloride	ug/m3	0.51 U	2.7 U	4.6 U	2.4 U	0.51 U

Notes:
U - Not present at or above the associated value.
J - Estimated concentration.
UJ - Estimated reporting limit.

ATTACHMENT A

STRATIGRAPHIC LOGS

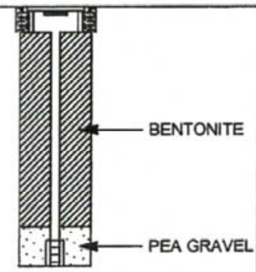
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: Columbus Avenue Facility
PROJECT NUMBER: 013048-10
CLIENT: General Motors Corporation
LOCATION: Anderson, Indiana

HOLE DESIGNATION: GP-1
DATE COMPLETED: March 31, 2008
DRILLING METHOD: DPT
FIELD PERSONNEL: N. Hill

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft ft AMSL	DPT	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	NORTHING: 1763842.53 GROUND SURFACE	893.4						
	EASTING: 326387.55 TOP OF RISER	893.1						
	FILL	892.4						0.0
2	CONCRETE	891.9		1		70		
	BRICK	891.7						0.0
4	CL-CLAY, sandy, firm, medium plasticity, brown, moist		BENTONITE					0.1
6								0.0
8				2		90		
	SP-SAND, silty, trace clay, compact, medium grained, dark brown, moist	884.4	PEA GRAVEL					0.0
10		883.4						
	END OF BOREHOLE @ 10.0ft BGS							

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48



WELL DETAILS
Screened interval:
884.4 to 883.4ft ft AMSL
9.0 to 10.0ft BGS
Length: 1ft
Material: PVC
Seal:
892.4 to 884.9ft ft AMSL
1.0 to 8.5ft BGS
Material: BENTONITE
Sand Pack:
884.9 to 883.4ft ft AMSL
8.5 to 10.0ft BGS
Material: PEA GRAVEL

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: Columbus Avenue Facility
PROJECT NUMBER: 013048-10
CLIENT: General Motors Corporation
LOCATION: Anderson, Indiana

HOLE DESIGNATION: GP-2
DATE COMPLETED: March 31, 2008
DRILLING METHOD: DPT
FIELD PERSONNEL: N. Hill

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft ft AMSL	DPT	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	NORTHING: 1763765.6 EASTING: 326620.62 GROUND SURFACE TOP OF RISER	893.6 893.3						
	FILL	892.6						0.0
	CONCRETE	892.1						
2	CL-CLAY, trace sand and gravel, brown based on soil boring log for MW15-00 approximately 60' northeast of GP-2		BENTONITE			0		
4		888.6	PEA GRAVEL					0.0
6	SP-SAND, silty, trace clay, compact, medium grained, dark brown, moist - based on soil boring from GP-1	887.6						
8	END OF BOREHOLE @ 6.0ft BGS							
10								
12								
14								
16								
18								
20								
22								
24								
26								
28								
30								
32								
34								
36								
38								
40								
42								
44								
46								
48								

WELL DETAILS
Screened interval:
888.6 to 887.6ft ft AMSL
5.0 to 6.0ft BGS
Length: 1ft
Material: PVC
Seal:
892.6 to 889.1ft ft AMSL
1.0 to 4.5ft BGS
Material: BENTONTIE
Sand Pack:
889.1 to 887.6ft ft AMSL
4.5 to 6.0ft BGS
Material: PEA GRAVEL

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

ATTACHMENT B

U.S. EPA'S SOIL GAS-ADVANCED MODEL
ATTENUATION COEFFICIENTS CALCULATIONS

DATA ENTRY SHEET: GP-1, Basement, Clay, Default Temperature

SG-ADV
Version 3.1; 02/04

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
79016	3.60E+03			Trichloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
200	274.32	12.5	200	74.32	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054	C	1.43	0.459	0.215				

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.25	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET: GP-1, Basement, Clay, Default Temerature

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	74.32	0.321	0.244	ERROR	0.003	9.97E-08	0.998	9.95E-08	4,000	3.60E+03	2.54E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.80E+06	2.22E-04	200	8,526	5.47E-03	2.34E-01	1.76E-04	1.28E-02	3.42E-03	0.00E+00	3.42E-03	74.32

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
200	3.60E+03	0.10	6.84E+01	1.28E-02	4.00E+02	1.55E+58	1.47E-03	5.31E+00	1.1E-04	4.0E-02

END

DATA ENTRY SHEET: GP-1, Basement, Clay, Soil Temperature = 16 C

SG-ADV
Version 3.1; 02/04

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
79016	3.60E+03			Trichloroethylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
200	274.32	16	200	74.32	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054	C	1.43	0.459	0.215				

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.25	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET: GP-1, Basement, Clay, Soil Temerature=16C

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	74.32	0.321	0.244	ERROR	0.003	1.00E-07	0.998	1.00E-07	4,000	3.60E+03	2.54E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.80E+06	2.22E-04	200	8,483	6.58E-03	2.77E-01	1.77E-04	1.28E-02	3.42E-03	0.00E+00	3.42E-03	74.32

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)
200	3.60E+03	0.10	6.84E+01	1.28E-02	4.00E+02	1.55E+58	1.47E-03	5.31E+00	1.1E-04	4.0E-02

END

DATA ENTRY SHEET: GP-2, Basement, Default Temperature

SG-ADV
Version 3.1; 02/04

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
79016	8.90E+02			Trichloroethylene

MORE

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
200	200	12.5	200	0	0	S		

MORE

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054	S	1.66	0.375	0.054				

MORE

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.25	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET: GP-2, Basement, Default Temperature

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	1	0.321	0.321	ERROR	0.003	9.97E-08	0.998	9.95E-08	4,000	8.90E+02	2.54E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.80E+06	2.22E-04	200	8,526	5.47E-03	2.34E-01	1.76E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	1

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)
200	8.90E+02	0.10	6.84E+01	1.28E-02	4.00E+02	1.55E+58	**2.69E-03**	2.39E+00	1.1E-04	4.0E-02

END